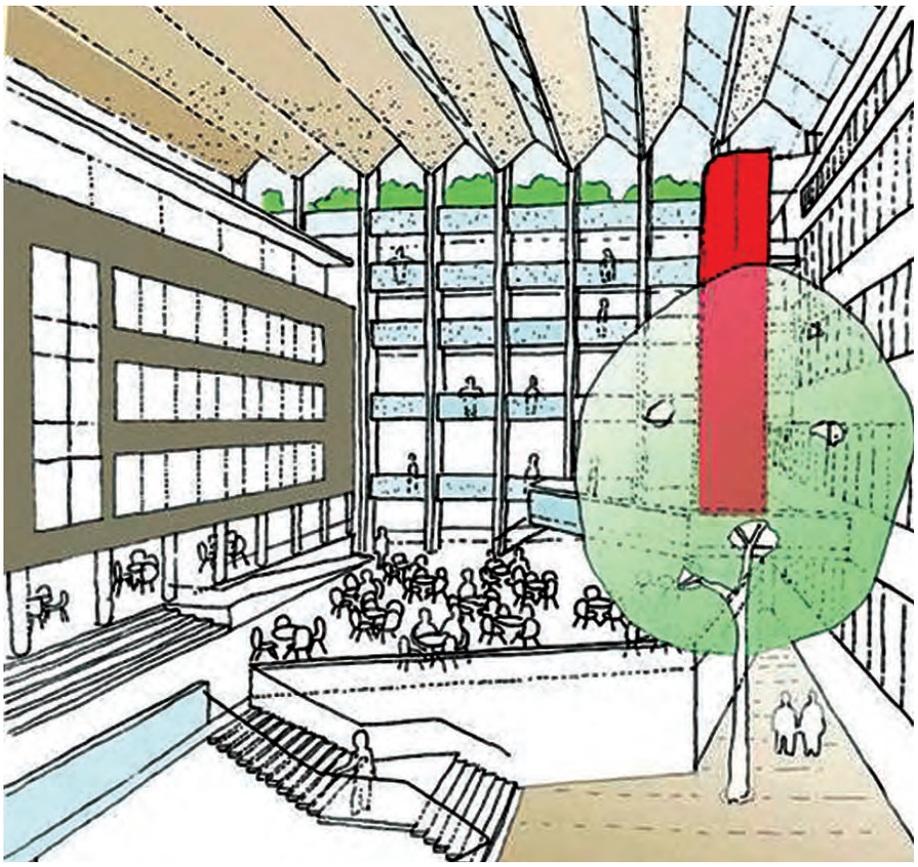
Newsletter

Issue 5 | Autumn 2007

UNIVERSITY OF CAMBRIDGE
Department of Engineering

Building for the future



An impression of the atrium which could replace the current courtyard (Nicholas Ray Associates)

The stories in this edition of the newsletter once again give evidence of the Department's world leading position in both teaching and research.

We have become increasingly aware, however, that the buildings and facilities on the Trumpington Street Site are far from world class: it is difficult to navigate around the Site; some of the labs and teaching spaces are no longer adequate; and the energy efficiency performance is poor.

Rather than make do with odd refurbishments and fixes, we decided we needed a long-term plan for the Site. We commissioned a scoping study by a team of architects: Nicholas Ray Associates. The first stage of the work has revealed that the Site can be brought up to an extremely high standard by making smart changes without having to flatten the existing buildings. By converting the central road to a glass-covered walkway, making an atrium in the courtyard and building above the Inglis Building and workshops, the disparate collection of buildings can become one integrated structure.

The overall guiding principles for the architects have been transparency and efficiency. Every activity in the Department will be on display, navigation will be easy without any hidden corners, and the carbon footprint will be dramatically reduced. We will apply our knowledge of energy, control, building engineering physics, and sustainability to achieve outstanding environmental performance. This aspect of the site will be used in teaching and the design will feature our latest research. The project will stand as an exemplar of low-carbon design, open to visitors from academia and industry, showing how buildings dating from the 1920s through every decade to the present day can be greatly improved.

"The project is not only about building an exceptional place on a prime site for our staff and students to interact, study and engage in world-leading research; it is also

In this issue

An integrated engineering department founded on core strengths spanning all engineering disciplines and also cross-connected by three strategic themes:
- **Cognitive Systems Engineering**
- **Engineering for Life Sciences**
- **Sustainable Development.**

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about putting first-class engineering on show for all to see how critical our work is for long-term economic, environmental and social sustainability. " said Professor Keith Glover.

We are greatly encouraged by stage one of the scoping study and are now planning stage two. This will widen the consultation to all staff in the Department, so that we can consider everyone's input and start putting some detail on the plans. Professor David Cebon is managing the study under Professor Keith Glover's leadership.

Needless to say, the building work will be expensive, albeit not as expensive as starting from scratch on a green field site. We have specified that the design must allow the work to be broken down into manageable chunks which are fundable and deliver tangible benefits. We believe that sponsors and donors will be attracted by our plans to make the Site a showcase for engineering research, teaching and sustainability. The first building on the Trumpington Street Site in 1920 was financed by a generous donation from an alumnus, Sir Dorabji Tata, who hoped that the "*enlarged school may be the means of imparting a fuller and more thorough training in the subject [of Engineering] to the thousands of students who will flock to it*". We are pleased to say that this fine original building still serves this purpose and will be retained along with the iconic Baker Building and many other familiar features, so that past students and staff will still recognise the place when they drop in to visit.

If you are a former student or member of staff and you would like to see the Department or share ideas, then please contact Philip Guildford (pg28@cam.ac.uk, +44 (0)1223 332671).

If you are a member of staff, then please keep an eye on the Department Bulletin for news of the scoping study and the numerous opportunities to participate throughout the study.

Options for an environmentally sustainable fashion industry

A new study by researchers in the Department's Institute for Manufacturing's (IfM) Sustainable Manufacturing Group, sets out a vision of a sustainable clothes industry outlining how consumers could satisfy their needs for clothes and textiles with significantly reduced impact on the environment, and at the same time offer new opportunities to retailers and manufacturers.

The report considers what could be done differently to make the industry more sustainable. Among other things, it recommends the use of more organic cotton, washing clothes at lower temperatures and encouraging consumers to buy fewer, higher quality, longer-lasting clothes as well as more second-hand garments.

Some retailers have begun to address these issues but industry-wide change would require the evolution of new business models. Suggestions such as a focus on durability in the fashion world, and business models that would focus on extra services like repair and maintenance show that profit and growth can be achieved.

"The aim is to help answer the question of what we should do to create significant change at the sector level," Dr Julian Allwood, from the Institute for Manufacturing, said. "We have focused on what might happen if we could make major structural changes to the way our clothes are made and used.

"For example, what would happen if we used different fibres or farming practices? What would be the consequence of washing our clothes in a different way, or keeping our carpets for longer?

"Businesses and the industry as a whole have to remain economically viable – or any change will have no benefit. The key to change is to ensure that government, industry and consumers work together to achieve a more sustainable clothes and textiles industry."

Among other things the report lays out a model for the ideal consumer, who would drive environmentally-beneficial changes in the clothing industry by, for example, buying fewer clothes, washing them less and recycling them more. At the moment, consumers in the UK spend about £780 per head per year on textiles and clothes, purchasing about 2.15 million tonnes (35kg per person). Of this, just one eighth is sent for re-use through charities and the rest is discarded.

The report is intended to be valuable to a wide range of interested groups. It is written for people in business – who have to balance their personal ethics and the concerns of their consumers with the need for their business to prosper. It is written for consumers who have a limited budget but are concerned about the impact of their shopping choices. It is written for campaigners and those in education, government and the media – to try to provide as balanced evidence as possible about the present and future impacts of the clothing and textiles sector.

If you want to become a greener consumer today, then you can by following a simple practical set of recommendations:

- Buy second hand clothing and textiles where possible
- Buy fewer more durable garments and textile products
- When buying new products, choose those made with least energy and least toxic emissions, made by workers paid a credible living wage with reasonable employment rights and conditions
- Lease clothes that would otherwise not be worn to the end of their natural life
- Wash clothes less often, at lower temperatures and using eco-detergents, hang-dry them and avoid ironing where possible
- Extend the life of clothing and textile products through repair
- Dispose of used clothing and textiles through recycling businesses who would return them for second hand sale wherever possible, but otherwise extract and recycle the yarn or fibres.

To download or order a hard copy (free + postage & packing) of the 84 page report entitled: "Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom" visit the IfM website www.ifm.eng.cam.ac.uk/sustainability/

Wind energy turns to bamboo

All the blades which power the world's growing number of wind turbines are made of composite materials.

However, from the beginning, the best blades have used wood – a naturally growing fibre reinforced composite material – as the primary structural material, comprising some 70% of the weight of the blade. This has been done because wood has superb fatigue behaviour and an unbeatable strength-to-cost ratio and it is also a low energy input material. Over 20 years the wood used has progressed from khaya (African mahogany) to poplar to Finnish birch, birch being the best wood available for this usage in the western world. The only wood available which has better properties than birch is bamboo and a supply route is now being developed for this material.

Bamboo, a sustainable resource, can be used as an alternative to energy-intensive fibres and polymers for this high technology application.

Since the early 1980s the best blades in the world, designed and manufactured in the UK, have used wood as the primary structural material. The early blades of this type have now completed over 20 years trouble-free service. Thousands of these blades have been produced and all follow the same structural pattern of using a hollow shell structure moulded in two halves, with a joining shear web inserted between them as they are bonded together. Typically wood comprises some 70% of the mass of the blade, with the remainder comprising glass cloth, resin and some metal inserts to create the bolted mounting joint at the root end of the blade.

A few years ago, Chinese material resources were rarely considered in relation to technical matters such as this. But bamboo outranks birch as the natural material with the highest properties available for this kind of application. And if notional values are given to good quality bamboo, the figures show that it outclasses even Finnish birch.

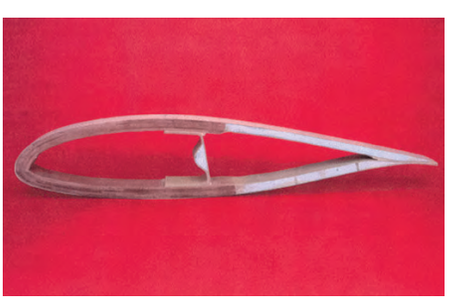
Dr Jim Platts from the Department's Institute for Manufacturing has worked for over twenty years on the design, development and manufacture of the large composite moulded blades for wind turbines, establishing the company Composite Technology (now part of Vestas) as a major contributor in that industry, currently producing high performance blades for wind turbines up to 120 metres diameter. Jim remains interested in the development of the wind turbine industry and technology and helping the industry develop in China.

China is poised to move swiftly to develop its own wind turbine industry to exploit its wind energy capacity which is as large as Europe's. China could so easily have followed the trend of the vast majority of wind turbine manufacturers in the world and used glass and carbon fibres in polymer matrices as the primary structural material for blades. However, Jim and his Chinese partners have shown that bamboo, a sustainable resource, can be used as an alternative to energy-intensive fibres and polymers for this high technology application. The use of bamboo in this way makes wind energy an even more attractive proposition for sustainable electricity generation.

Above left: Wind turbine blade manufacture

Above: Bamboo Forest

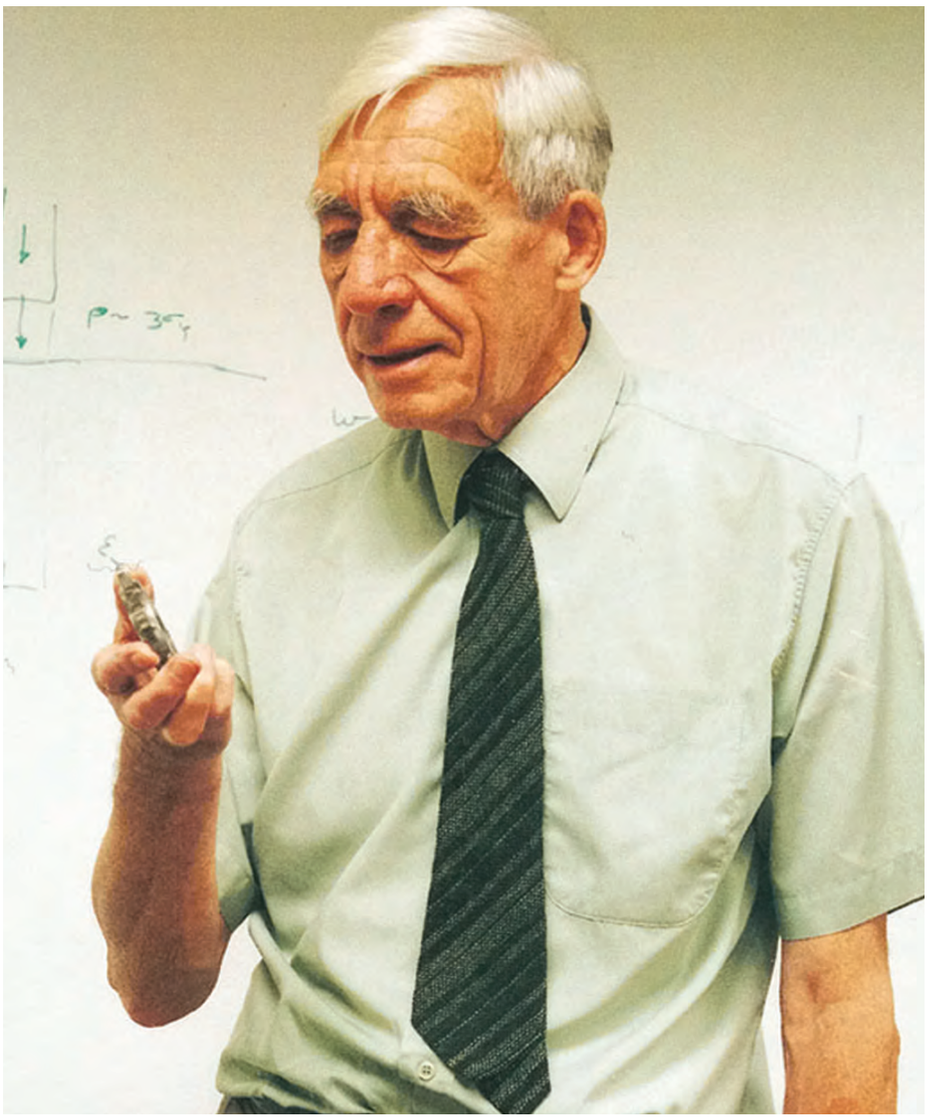
Below: Wood Composite Blade Section



For further information please contact Jim Platts email: mjp@eng.cam.ac.uk More information about Jim's work on wind turbine blades and bamboo can be found in the Institute of Materials Journal "Energy Materials" 2006 Vol 1 No 2, pp 84-7.

Professor Kenneth Johnson awarded the Timoshenko Medal

Professor Kenneth Johnson FRS, FEng has been awarded the prestigious Timoshenko Medal. Professor Johnson is an Emeritus Professor of the Department and has worked in the field of contact mechanics and tribology for forty years; he retired after more than thirty years on the staff here. He is the author of the book Contact Mechanics (Cambridge University Press, 1985) and was awarded the Tribology Gold medal in 1985, the ASME Mayo D Hersey medal in 1991 and the Royal Society Medal in 2003.



Professor Kenneth Johnson photo courtesy of iMechanica

Below is the 2006 Timoshenko Medal acceptance speech made by Professor Johnson as published on the iMechanica website.

"First and foremost, I must acknowledge with gratitude the honour of being selected for the Timoshenko medal for 2006. But since a speech is now expected, I realise that this is not a free lunch. If you know a good pub, this would be a good time to slip away.

"When I received Virgil Carter's letter informing me that I had been selected, I could not believe it. There must have been a mistake; after all Johnson is a very common name. I am reminded of my first meeting with Bernie Budiansk from Harvard, also a Timoshenko medallist. He asked, 'Did you write that book on vibration with Bishop?' 'No. That was Dan Johnson'; 'Did you edit that British Journal of mechanical sciences?': 'No. That was Bill Johnson'; 'Who the hell are you?'

"I must belong to a shrinking number of Timoshenko medallists who actually met the great man himself, that is if 'met' is the right word. It was at the 1956 IUTAM Congress in Brussels. He was always surrounded by KGB men in long black coats. It was impossible to get near enough to see the white of his beard.

"However, I can claim to be a good friend of his side-kick: Norman Goodier, Timoshenko medallist in 1963 and co-author of his famous book on The Theory of Elasticity. Goodier graduated in Engineering from Cambridge, (England, that is!) and came to the United States on a scholarship to the University of Michigan, where he met Timoshenko. Interestingly for me, Goodiers' Cambridge PhD Dissertation contained a report of an investigation into corrugation of railway rails. It showed rather more progress on that problem than I managed to make 50 years later.

"When Timoshenko emigrated from Russia to the US, he found it an undeveloped country as far as mechanics was concerned, which led to the foundation in 1927 of the Applied Mechanics Division of ASME, with Timoshenko as first chairman. No doubt he was pleased to find an acolyte with a sound Cambridge training in mechanics. Goodier capitalised on the situation in the time honoured way, by 'marrying the boss' daughter'.
"I have occasionally been asked how I first got involved in contact mechanics. My first job after graduation, towards the end of World War II, was working in the aircraft industry as a vibration engineer. The company Rotol, designed and

manufactured most of the aeroplane propellers in active service. This included the Spitfire fighter, famous from the Battle of Britain. The increase during its lifetime of the power of the Merlin engine demanded that the propeller required an increasing number of blades. When I signed on it had reached five, which gave rise to severe vibration. Working on this problem, I found drawing vector diagrams at 72 deg. gave an invaluable training in dividing a cake or a pie equitably for what turned out to be a family of five.

"In common with vibration analysts then and since, I worried about assessing the damping. I became convinced that in most practical cases of structural vibration the damping arose principally by slip at clamped joints. On returning to the university I made this the subject of my PhD. This topic brought me into close contact with R.D.Mindlin and his group at Columbia University, who were studying Hertz contact under the action of tangential friction forces. That was the start.

"During my time as a graduate student I was profoundly influenced by three books: Timoshenko and Goodiers' Theory of Elasticity; Den Hartog's Mechanical Vibrations and Bowden and Tabors' Friction and Lubrication of Solids. I tried to copy the simple and direct style of all three when I came to write my own book on Contact Mechanics. I have been fortunate that contact mechanics has become an expanding field. In the early days I had a visit from Don Conway of Cornell, who expressed surprise that any one could fill their time with contact problems!

"The IUTAM Congress in Brussels provided another lucky break in my career. A bus trip to the historic city of Bruges had been arranged for the middle Sunday. My wife came out to join me on the Saturday night. Being newly weds, we were late at the departure point on Sunday morning and just managed to catch the bus reserved for late-comers. For whatever reason, the rest of the latecomers comprised a 'who's who' of applied mechanicians. When we arrived at Bruges a party led by Mindlin and Drucker made for a restaurant in the main square, where Dorothy and I found we could hardly afford a bowl of soup. With very red faces, we extracted ourselves, shortly to be followed by the rest of the party. Sandwiches were acquired to be eaten on a hilarious boat trip round the canals. Sometime later I received an invitation from Dan Drucker to spend a year at Brown in its glory days, which confirms that it's not what you know, but who you know which counts. I shall not forget that happy year, which not only produced a son with an American passport, but also friendships which have stood the test of time. Brown doesn't seem to have forgotten it either. Only the other day I received an invitation to a fundraising event in London.

"During my time as a graduate student I was profoundly influenced by three books: Timoshenko and Goodiers' Theory of Elasticity; Den Hartog's Mechanical Vibrations and Bowden and Tabors' Friction and Lubrication of Solids.

"I must also take this opportunity to acknowledge my debt to David Tabor, who died last year aged 92. He not only invented the word 'tribology', but along with F.P.Bowden in the Cavendish Laboratory in Cambridge, he established the subject as a respected scientific discipline. Many members of ASME look back with pleasure and satisfaction to time spent in that laboratory. It seemed to be my role to use continuum mechanics to show that the results of Tabor's intuition plus simple experiments could hardly be improved upon. It is noteworthy that the word 'tribology' has been accepted throughout the world, even including the US, which tends to oppose fancy new words from Europe, like 'kilogram' and 'centigrade' ; perhaps because they are French!

"About the time I formally retired from teaching in '92, microprobe instruments such as the Atomic Force Microscope and the Surface Force Apparatus were being developed, mainly in physics departments, and used to study friction on the atomic scale. Irwin Singer of the Naval Research lab, in Washington, observed that this activity was going on in complete isolation from the traditional world of engineering tribology. He organised a NATO ISA in Braunlager to bring the to communities together. It was an eye opener for both sides. My activities changed quite dramatically from wheel/rail contacts, whose diameters are about 10 mm, to contacts of a few micro-metres or less. At this scale molecular adhesion between the surfaces becomes a major effect. This meant that I had to make friends with physicists, for whom friction has suddenly become a fashionable subject. Maybe they will be able to explain the question that so exercised Bowden and Tabor 60 years ago: the relation between adhesion and friction. They picked up a paper of mine on adhesion in Hertz contacts, written in '71 with two graduate students: Kevin Kendall and Alan Roberts which suddenly became famous as the 'JKR theory'. To bask in this celebrity my co-author Alan Roberts recently entered JKR into Google was rewarded by pages and pages of citations...to J.K.Rowling, the author of Harry Potter.

"A few years ago I was nominated for an award in tribology to be presented by the Duke of Edinburgh. At the time his youngest son Prince Edward, was a final year undergraduate at my College. It was a case of, 'Please God, may that boy pass his exams. I have to face his father next week!' At the presentation the citation mentioned 'shakedown in rolling contact'. The Duke asked me to explain 'shakedown'. I mumbled something about repeated loads on structures doing damage at first, but improving with time. He looked at my wife and said, "Just like married life". Well, I suppose it depends who you are married to.

"One of the pleasurable features of living and working in Cambridge is its attraction for distinguished visitors, who find it a convenient base camp for the 'Grand Tour of Europe'. Some even do some work. I felt a warm glow towards Tom Farris when he began a conference talk by saying: "This idea originated in the coffee room at Cambridge". Of course the reverse also applies. My wife and I have received wonderful hospitality and acquired firm and lasting friendships on our trips around the world, particularly the US. We thank you all."

FACT BOX

The Timoshenko Medal, widely regarded as the highest international award in the field of applied mechanics, was established in 1957 in honour of Stephen P. Timoshenko, world-renowned authority in the field. The award is given annually by the American Society of Mechanical Engineers (ASME) to an individual "in recognition of distinguished contributions to the field of applied mechanics."

Engineering students sweep the board in Monaco

The TouchSight team

Engineering students have triumphed yet again in an international competition for young entrepreneurs with a product designed to help blind and partially-sighted people.

The TouchSight Vision Mitt – designed by a team of four manufacturing engineering students – took first prize, worth 10,000 Euros, at the Next Generation Entrepreneur Forum (NGEF) competition in Monaco.

TouchSight, a new startup company started by Manufacturing Engineering Tripos (MET) students Pete Davies, Karan Keswani, Samaan Rahman and Jessi Baker, beat off five other teams from leading institutions around the world. To do so, they faced the daunting task of pitching to an audience of 200 people, most of them successful venture capitalists, and were then quizzed by a panel on stage.

Their winning invention is a glove-shaped mobility aid that enables the user to "sense" their surroundings using ultrasonic sensors and vibration feedback actuators – a low cost alternative or supplement to white sticks or guide dogs.

Last month the same team won the new Varsity Pitch competition between Cambridge and Oxford, dubbed "the business boatrace". In January the team was one of 10 winners in the Cambridge University Entrepreneurs Business Ideas competition.

The NGEF event is a three-day networking competition attracting many venture capitalists and business angels, and offering students a chance to win international exposure.

The TouchSight Vision Mitt

TouchSight won particular praise for its social entrepreneurship from Candace Johnson, the co-initiator of the Astra satellite system and SES global, one of the world's largest satellite systems. Pete Davies said: "We have learnt a huge amount about entrepreneurship and have met amazing people from around the world with similar interests and great connections. TouchSight will now take the next steps to bring the product to market. We will build more prototypes and work more closely with distribution channels to make this happen. Hopefully we will bring real change to the lives of the blind and visually impaired across the world."

For further information please contact ifm-enquiries@eng.cam.ac.uk

Nokia and University of Cambridge to partner on research: joint research projects will initially centre on nanotechnologies

Electrical Engineering Building

Nanoscience Centre
Photo courtesy of Phil Wigglesworth

Nokia and the University of Cambridge have announced an agreement to work together on an extensive and long term programme of joint research projects. Nokia Research Center (NRC) will establish a research facility at the University's West Cambridge site and will collaborate with several departments – initially the Nanoscience Centre and Electrical Division of the Engineering Department – on projects that, to begin with, will be centred on nanotechnology.

Nokia will initially base around ten people at Cambridge: the agreement is intended to be long-term and the number of Nokia researchers based at the university is set to rise steadily over time. A joint steering committee has been formed and will be responsible for directing the research strategy and for the selection of research projects. The collaboration will initially focus on nanoscience – studying innovative new materials, phenomena and manufacturing solutions for areas including energy sources, sensors and computing.

Dr. Tapani Ryhanen heads Nokia global research in the nanotechnology area, and will lead Nokia's collaboration with Cambridge. He added: "Nanotechnology long ago left science fiction movies for the laboratory and, more recently, we saw the first commercial applications. The techniques we are developing really bring us a toolkit for working with the processes of nature at a very basic level – the level of molecules – in a safe and controlled way."

"Cambridge and Nokia share a common belief in the ability of nanotechnology to deliver products and applications of tangible value to people," commented Professor Mark Welland, Director of the IRC (Interdisciplinary Research Collaboration) in Nanotechnology at Cambridge. "The fact that we also share a common commitment to the responsible introduction of nanotechnology into the public arena adds a further unique dimension to this collaboration."

For more information on Electrical Engineering Division please visit www.eng.cam.ac.uk/research/div-b/divhomeB.shtml. For the Electronics, Power and Energy Conversion group please visit wwwg.eng.cam.ac.uk/epec/ and for the Nanoscience Centre please visit www.nanoscience.cam.ac.uk/centre/index.html

FACT BOX

The academics from the Department leading the collaboration are Professors Gehan Amaratunga, Bill Milne and Mark Welland (above).

Alumnus wins an Oscar for his special effects software

Alumnus Dr Anil Kokaram was awarded an Oscar for his visual effects software used in a string of Hollywood blockbuster films. The Academy of Motion Picture Arts and Sciences ceremony took place in Los Angeles, two weeks ahead of the glitzy film awards. The Scientific and Technical Awards, hosted by actress Maggie Gyllenhaal, were presented for inventions of special value to film.

Anil Kokaram

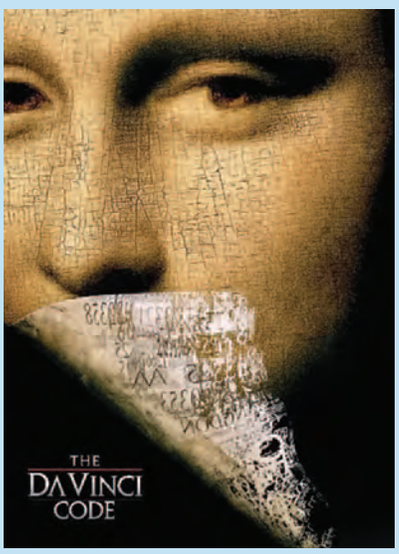
Anil, now a lecturer at the Department of Electronic and Electrical Engineering, Trinity College, Dublin, worked as a consultant with the UK based software developer, The Foundry – www.thefoundry.co.uk. Anil received the Scientific and Engineering Award along with three members of The Foundry software team.

Anil commented on his time at the Department; "I did my PhD in the Department of Engineering under Professor Peter Rayner and this work was the foundation for what I have done with The Foundry. Up till 1998 I was a Research Associate at the Signal Processing Group and I am still in touch with the group. My PhD was in fact a continuation of a lot of work done in that laboratory in audio restoration. Motion estimation turned out to be an important part of that work and my PhD (which I got in 1993) was about algorithms for motion picture restoration. While at Cambridge I was involved with a number of EU projects and on one of those projects I met with Dr Bill Collis. He figured some of the things I was doing in video processing could be used in special effects for movies and so asked me to come and speak to The Foundry in 1999. In essence they asked me to solve parts of problems that they had and we have been working together since then. Bill was involved with the original effects for the film 'The Matrix' and that encouraged him to think that motion estimation was important for the future of cinema post production. The first problem I worked on for The Foundry was removing objects in movies using motion and background interpolation."

Anil and his colleagues have developed a software package which performs tasks which were previously very difficult to carry out at a post-production stage unless manual editing was used. Anil has particular expertise in motion estimation which is required for many special effects and enhancement operations in motion pictures or videos. In a given film, 25 pictures or frames are taken every second. Through motion estimation, the group developed algorithms capable of tracking the movement and properties of every pixel in a frame in relation to the corresponding pixels in subsequent and preceding frames in a sequence. The software uses motion estimation for a wide range of material to create unique special effects and also perform touch-up tasks that were previously manually done – such as removing blotches or creating new frames in an image sequence.

FACT BOX

The Foundry software has been used on films including 'Casino Royale', 'X-Men' and 'The Da Vinci Code'.



COURTESY OF SONY PICTURES

Department hosts seventy physics teachers for weekend of workshops

Teachers very impressed with the range of experiments offered to the students - this one is on fluid flow and heat transfer.

An experiment to locate the nodal points on a vibrating bar

The Institute of Physics (IOP) organises 'Physics Update' events devised to update physics teachers on innovations in physics, both pure and applied, and in curriculum matters. "Hands-on" workshops afford teachers opportunities to try new equipment, develop new IT skills, learn new experimental techniques, try out novel investigations and engage with alternative teaching and learning strategies. The last update event was held here at the Department of Engineering hosted by Hugh Hunt. One teacher tells us more about the successful event:

Attending the Institute of Physics (IOP) Physics Update in the University of Cambridge Department of Engineering and Trinity College, Cambridge,

"There's something delightful about becoming a physics student again for a weekend in the middle of a busy term of teaching. When you ring the IOP Teachers' Update team to enquire about available places Leila Solomon makes you feel so welcome that you want to encourage a couple of friends to go along as well. So this year veteran participant John Murphy, CBS, Dungarvan was joined by three new wide-eyed disciples : Noel Brett, Colaiste Chriost Ri, Cork, Paul Nugent, St Dominic's High School, Sutton and Michael Grehan, Belvedere College, Dublin. Cambridge University was an inspiring venue for this Physics Update. By breakfast time we had walked in the footsteps of great Physicists and Engineers. In the Great Hall of Trinity College we dined under portraits of Sir Isaac Newton, James Clerk Maxwell and Ernest Rutherford. Most of our practicals took place in the Department of Engineering where Sir Frank Whittle pioneered Jet Propulsion.

We were warmly welcomed and shown around Trinity College by our local host, Dr Hugh Hunt, who generously brought the event to Cambridge on this occasion. Hugh's enthusiasm matched his intimate knowledge of Trinity College as his guided tours continued long after dark and even wound up with a dizzying visit to the clock tower on the second evening! The particular qualities which enriched this IOP Physics Update were the enthusiasm and generosity of the 92 participants; qualities common to the distinguished presenters and the many teachers who freely shared their ideas and inventions with others. The event was also made possible by generous sponsorship from the Armourers and Brasiers' Company (1322), which has an ancient tradition of charitable giving, and from Canadian corporation Novelis.

What strikes me most about Professor Sir Martin Rees is his relaxed, friendly personality and his skill in replying to questions.

Dr Hugh Hunt is the man to ask about vibrations and harmonics, One of his many demos was simply a metal tube about 2m long. Skilfully held at various different nodes, this produced a remarkable range of musical notes and of tonal quality. "We are all to some extent musical and in music we find beauty".

It's not every day you get treated to a lecture on the Great Laws of Physics by the Director of the Cavendish Laboratory – and that was a treat. Professor Malcolm Longair gave us fascinating insights into the creativity and ingenuity behind some big discoveries. Picture Faraday starting a revolution in 1831 by inventing field lines though he "knew no mathematics" – and again the intuitive way Maxwell used "analogies in nature" and wrote new mathematics to achieve the theoretical unification of light and electromagnetism. As Freeman Dyson has said: "Maxwell's theory had to wait for the next generation of physicists, Hertz and Lorenz and Einstein, to reveal its power and clarify its concepts."

On Saturday afternoon we had the honour of meeting the Master of Trinity College who has so many distinctions that I don't know how to give him his proper title.

Teachers looking at an experiment on open-channel water flow

Hands-on physics - Lecture room 5 has never seen so many toys!

What strikes me most about Professor Sir Martin Rees is his relaxed, friendly personality and his skill in replying to questions. His lecture on dark matter opened up, for me, more of those surprises with which the Universe is so richly endowed. One of them tells us that in the Universe at age 10 –12 seconds all the particles had more energy than in CERN – and "We need much more physics to understand this". He reminded us that our Sun is a second or third generation star. So the heavier atoms in our bodies were made in supernova explosions and we have within us the ashes of dead stars. I went home with even more of a sense of wonder, reflecting on the astonishing events which got us here on this precious little planet.

What have the following got in common? A spinning top which keeps going for a whole workshop, another which levitates in mid-air, a third which inverts itself and continues to spin (courtesy of Euler's formula), a see-saw driven by a candle flame, a solid looking black disk which allows a pencil to pass though it freely, a Newton's cradle using magnets and a host of colourful optical illusions? They were among the physics toys we enjoyed playing with during the practical led by David Featonby who is IOP Teacher network coordinator for the North East. My students would have been enthralled too and described David as "ledge" – and a legend he is.

Space does not allow a proper sample of the delights of this IOP feast. They included the secrets of the electric guitar and Fourier Series (Nick Weaver), the Physics of the Sun (Dr Helen Mason), the real reason why an aircraft flies, shown in a real wind tunnel (Dr Holger Babinsky), Materials of the future (Professor Lindsay Greer) and probably the most practical treasure of all: The Virtual Physical Laboratory – a wonderful suite of on-screen simulations created (presumably over thousands of hours of work) by Dr John Nunn, supported by the National Physical Laboratory.

The whole experience had been so uplifting that we hardly felt the need for Holger Babinsky's explanation of Bernoulli's principle as we raced down the runway at Stansted.

After lunch on Sunday we said our goodbyes to Leila Solomon, Hugh Hunt, David Featonby, John Nunn and other inspiring educators. The whole experience had been so uplifting that we hardly felt the need for Holger Babinsky's explanation of Bernoulli's principle as we raced down the runway at Stansted. The good news is that the IOP are at it again: Birmingham at the end of March and Cardiff in early July. I would warmly recommend any science teacher who is interested to apply for future IOP Physics Updates. They are as enjoyable as they are informative. Many many thanks to the organisers of the Cambridge event for an enriching experience of Physics Education at its best.

Michael Grehan,
Belvedere College, Dublin.

For more information on the Institute of Physics please visit www.iop.org

FACT BOX

The Institute of Physics:

- **Builds networks of physicists based on technical and professional interests**
- **Publishes an internationally acclaimed range of magazines, journals, reference works**
- **Allows access to a range of award-winning web sites for members, students, graduates, teachers and school children**
- **Actively promotes physics to external audiences, working to increase awareness importance of physics in education and industry**
- **Provides careers advice and guidance for physicists at all career stages**

Engineering students win varsity competitions

Jake Cornelius and Tom James win the Boat Race

Tom James middle, Jake Cornelius left

Jake an MPhil. student on the Department's Engineering for Sustainable Development course, was part of the winning Cambridge crew in the Boat Race on Easter Saturday. Talking about the race, Jake said, "Participating in the Boat Race was an experience I will never forget. The training brought me extraordinarily close with my team-mates, and the race itself was a true test of character that helped me grow a lot personally. The pressure before the race is unreal. In the US, rowing is not a high-priority sport, so all the attention was a big shock to me. All the attention made it an especially stressful race, so in many ways I am glad it is over."

Jake began Rowing in 2000 in the US for Cascadilla Boat Club. In 2006, while an undergraduate in Mechanical Engineering at Stanford University, he rowed for the US National Team Under 23.

It was a particularly sweet victory for Cambridge president and Engineering undergraduate Tom James, who finally became a Boat Race winner at his fourth and final attempt.

"I didn't really want to think about losing again. I don't know what I would have done, but I wasn't thinking beyond this race," he said.

"We knew they were going to hammer off the start and we had to stick to our guns and keep moving. "We kept pounding and coming down the straights. It was just a matter of listening to the calls and staying on your blades.

"Having lost three times, it's a great relief not to be in that situation again." Tom, who was in the GB first eight in the Athens Olympics, had little time to recover after the Race as he went straight on, with fellow Cambridge crewman Kieran West, to the GB National Trials for the 2008 Olympics.

Duane Rowe wins the Varsity Chess Match

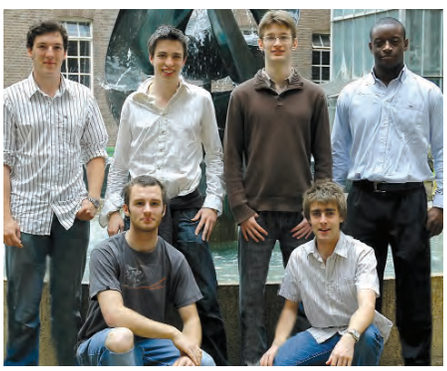
Duane Rowe an MPhil. student on the Department's Engineering for Sustainable Development course has represented Cambridge University in the recent 125th Varsity Chess Match against Oxford University, which was held on March 10, 2007 at the Royal Automobile Club in London. Cambridge won the match with a score of 5-3.

Duane won the Cambridge Best Game prize for his spectacular game against Women's International Master (WIM) Olena Boytsun. Duane says it feels very satisfying to have participated in this prestigious and traditional varsity event, which has earned him a half blue.

Duane is the current and a four-time National Chess Champion of Jamaica where he is a "National Master" – a title he received in 1996. He has represented his country in the last four World Chess Olympiads in Turkey 2000, Slovenia 2002, Spain 2004 and Italy

The Royal Academy of Engineering Leadership Awards

The 2007 Royal Academy of Engineering Leadership Award winners have been named and include 6 second year students from the Department. Congratulations go to: Emmanuel Akinluyi, Robert Fryers, Alex Mansfield, Ben Sheppard, Jonathan Smith and Paul Thomas.



2007 Royal Academy of Engineering Leadership Award winners

The objective of the Engineering Leadership Awards is to allow outstandingly able engineering undergraduates, with marked leadership potential, to undertake an accelerated personal development programme. They will be afforded the opportunity to acquire and enhance the necessary skills required to fulfil their potential in preparation for fast track executive careers in the engineering industry.

The Engineering Leadership Awards provide motivation and support for some of the most exceptional engineering undergraduates in British universities, with the potential for high-level industrial leadership. Awards worth up to £5,500 per student are made to provide MEng students, over two or three years, with carefully planned training and experience.

For more information please visit www.engineeringleadershipawards.org.uk/

Photography competition winners

This year for the first time there were two categories in the Department's photography competition, one for staff and students the other for alumni. As you will see on these pages the quality of the images entered was exceptionally high, revealing some of the hidden beauty that lies within engineering.

The competition, now in its fourth year, is sponsored by Owlstone – a nanotechnology company, which was spun out of the Department's research. All of the Department's staff and students can enter the competition. The aim is to find the best images that highlight the research being undertaken by engineers, both in the lab and in the field.

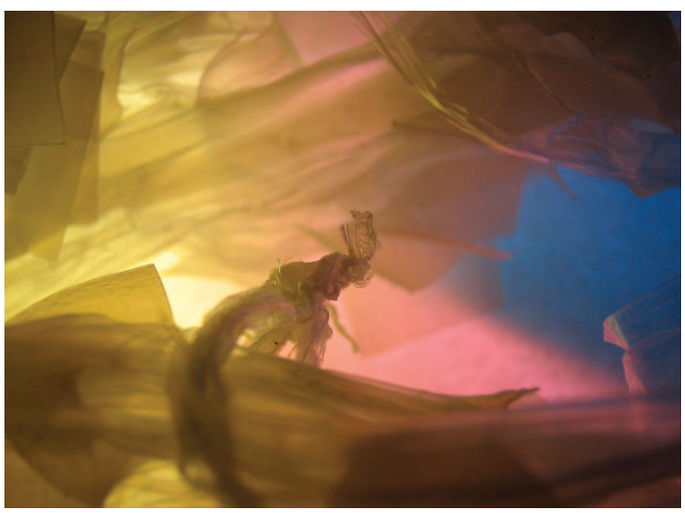
Spectacular images, ranging from microscopic nano-art to entire coastlines glimpsed from space.

Other entries that were highly commended by the panel of judges reveal the fantastic inner structures of everyday objects, offer glimpses into microscopic nano-worlds, or simply give a new, perhaps unusual perspective on the experiences of engineers working in the field.

The winning photograph 'Earth from 32km'

This year's winning entry was taken from a space craft launched by a team of undergraduates from the Department of Engineering – Henry Hallam, Robert Fryers, Carl Morland, Daniel Strange and Iain Waugh. The students set themselves the goal of launching a rocket into space for less than £1000. Their spectacular winning image of the curvature of the Earth from the upper atmosphere resulted from an early trial using a high altitude helium balloon to launch their tiny payload, no bigger than a lunchbox. Packed with instrumentation, it flew to nearly four times the height of Everest before descending by parachute, taking photographs throughout the flight. The winning team are part of Cambridge University Spaceflight, a student-run organisation composed mainly of engineering undergraduates who are developing balloon and rocket technology to enable cheap experiments in the near-space environment.

The photograph has so impressed staff within the Department of Engineering that the team have now been offered 25 hours of workshop time to develop their project further, in addition to the Owlstone cash prize.



Amanda Wycherley, 'Polymer Life'

Sam Jewell, 'Ripples in steel ocean'

'Bricks', taken by Chas Pope

The winning image in the Alumni Photography Competition, 'Bricks', was taken by Chas Pope. Chas describes the photo as 'The basic building blocks: piles of bricks can be found everywhere on Chinese construction site, some neatly arranged, others veering off at unlikely angles like a half-finished game of Jenga.'

He went on to say, 'Since graduating from Cambridge University nine years ago. I have been working as a structural engineer with Arup. I have concentrated on multidisciplinary building engineering design, spending five years in London before moving to the Beijing office in 2003. My work in China has concentrated on projects related to the 2008 Olympic Games, in particular the design of the gravity-defying CCTV Headquarters Building which is now taking shape in the city. I am currently working on other projects in Beijing and the East Asia region.'

Other entries in the Department's 2007 alumni photography competition can be seen at www.eng.cam.ac.uk/photocomp/2007/alumni_entries/

FACT BOX

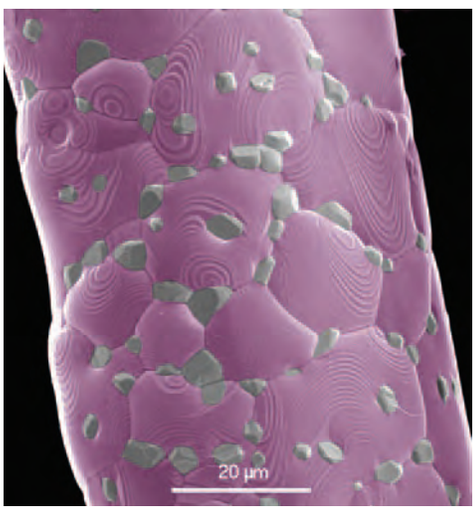
Entries for the two categories in this year's photography competition (one for staff and students the other for alumni), can all be viewed, along with the winning and commended entries from previous years, on the Departmental website, at www.eng.cam.ac.uk/photocomp/2007/

For more information contact:
Carl Morland email:
cm471@cam.ac.uk
Henry Hallam email:
hmh33@cam.ac.uk
Robert Fryers email:
rjf44@cam.ac.uk

Cambridge University Spaceflight:
www.srcf.ucam.org/~cuspaceflight/

Owlstone:
www.owlstonenanotech.com/

Ian Ball, 'Checksarian Source'



Athina Markaki and T.W. Clyne, 'Surface Steps on a Stainless Steel Fibre'

Dick Fenner, 'Beam me up !!'

Engineering for the Life Sciences

Gábor Csányi

Alexandre Kabla

Athina Markaki

Michelle Oyen

Engineering for the Life Sciences is a major new initiative in the Department led by Professor Daniel Wolpert, which provides interdisciplinary training between engineering, biology and medicine and focuses on:

- Understanding living things through application of engineering sciences including engineering principles of molecular biology, bioinformatics, mechanics of biological tissues, systems physiology, and neuroscience.
- Developing devices, algorithms and processes that advance biology and medicine including biomaterials, biomedical imaging, application of microelectromechanical systems for biological sensing (BioMEMS) and biomimetics.

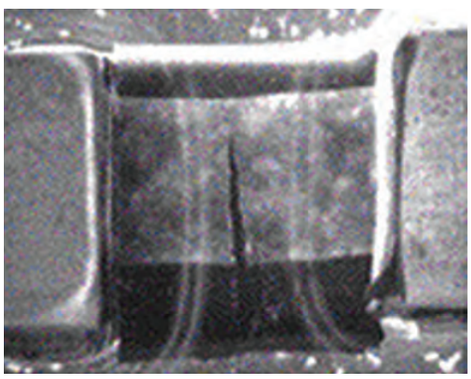
There is a growing need for a quantitative understanding of biological systems and for development of novel devices. This field is rapidly expanding with the number of jobs in biological engineering predicted to grow strongly over the next decade. The Department's new initiative addresses this need both with world-leading research and excellent undergraduate teaching.

Four new lecturers have joined Professor Daniel Wolpert and Professor Norman Fleck to undertake research and teaching in this important new interdisciplinary engineering area.

Gábor Csányi joins us from the Theory of Condensed Matter Group of the Cavendish Laboratory as a Lecturer in Micromechanics. His research focuses on developing algorithms to carry out molecular dynamics simulations of complex materials from composites to proteins. Gábor is "amazed and delighted" by the diversity of research interests existing in the Department and says "I hope to be able to apply some of the techniques I have been working on to better understand the mechanics of molecular systems."

Alexandre Kabla joined the Engineering for the Life Sciences group in April 2007. His main research activities focus on the mechanical properties of soft disordered materials, including foams, granular materials, as well as biomaterials and living tissues. Current interests are fibrous networks rheology and embryo-morphogenesis. Within the Engineering for the Life Science group, Alexandre plans to develop experimental approaches to distinguish passive and active responses of tissues, with applications ranging from fundamental biology to tissue engineering. The strength of the Department in micromechanics and imaging techniques, together with the proximity of high caliber biology groups, will provide a perfect environment for this work.

Athina Markaki joins us from the Department of Materials Science & Metallurgy as Lecturer in Engineering Materials. Her research interests include work on strengthening of prosthesis-bone bonding by "magneto-mechanical actuation" of fibre network materials for which she won the De Montfort Award at "SET for Britain" 2004 (Supporting Britain's Younger Scientists, Engineers & Technologists). Athina is delighted to join the Department of Engineering. She says:



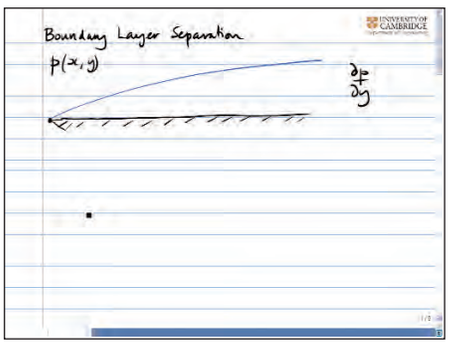
A crack propagating through engineered cartilage during fracture toughness testing

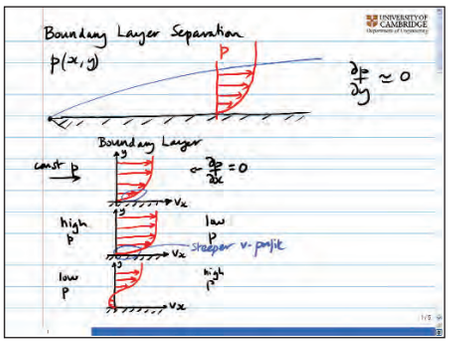
"The Department offers facilities, expertise and a general environment, which is well suited for my research. I am very excited at the prospect of using my mechanical and materials background to help develop a new biomedical treatment."

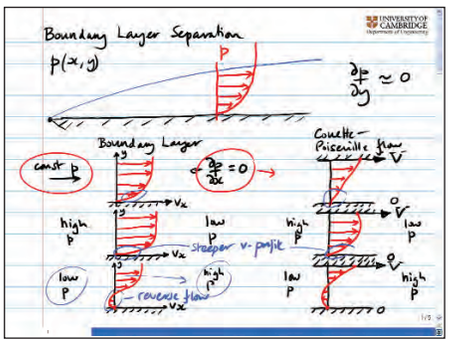
Michelle Oyen joins us from the University of Virginia as Lecturer in Mechanics of Biological Materials. Her research emphasis is on the time-dependent mechanics of materials, primarily considering hydrated biological tissues. The applications are related to both the identification of measurable changes in biological tissue mechanical properties for disease identification and injury prevention/repair of damaged tissues with mechanically suitable replacements. Specific interests include viscoelastic measurements from depth-sensing indentation (nanoindentation) experiments; time-dependent deformation and fracture of soft tissues; structure-properties relationships in natural and biomimetic organic-inorganic composites; and mechanical factors in clinical obstetrics.

Audio-visual teaching aids for students

Matthew creating the animations







Dr Matthew Juniper of the Energy group at the Department has created a set of online animations to supplement lectures for his students.

Initially Matthew was keen to save time when repeating basic concepts and problem solving techniques in supervisions. He decided to create animations that show him describing a concept in real time, with a tablet PC recording both his handwriting and a running commentary. Often there are many ways to explain a concept but in a lecture there may only be time for one explanation. The animations allow students to explore another version that might make more sense to them.

Matthew went on to create animations of worked examples related to the example paper questions that the students do before supervisions. Students who are stuck on a particular part of an examples paper question can watch the worked examples at their own pace and may get the hint they need to complete the question by themselves. This can free up time in supervisions for discussion of the concepts.

In 2005/06 Matthew trialled the animations on the 3rd year Fluid Mechanics students as part of a study by the Cambridge-M.I.T. Institute. The additional materials had a positive effect on all the measured aspects of supervisions, particularly on the students' ability to answer the questions and on students' conceptual understanding. One student said "I found the audio-visual presentation particularly helpful because I could replay it on demand." A supervisor found that "the students who used the additional materials could get a lot further in the questions. Those who did not use them despaired and gave up, expecting to be told all in the supervision." Students found these aids very useful, particularly when a new concept was introduced, and for exploring the most difficult concepts. They now form part of the 2nd year Fluid Mechanics course.

The University of Cambridge's 'Centre for Applied Research in Educational Technologies' (CARET) www.caret.cam.ac.uk/ whose services are available to those within the university wishing to use technology to support research, teaching or learning, have helped Matthew develop his methodology for creating the teaching aids. John Norman director of CARET has shown the teaching aids to many experts in the field of online teaching materials, and has had nothing but extremely enthusiastic feedback on Matthew's technique for economic and rapid production of such high quality content.

Matthew is keen to show other lecturers how easy it is to create the animations and that in the long term they will not only save teaching time but help to achieve better quality teaching. He has given talks at the Department and he has also created a website that shows some examples of the animations and describes the process in more detail.

This can be found at www2.eng.cam.ac.uk/~mpj1001/AM_website/index.html

NASA astronaut, alumnus Nicholas Patrick, visits the Department

Nicholas talking about the mission

Cambridge engineering graduate Nicholas Patrick (Trinity, 1982) visited the Department in April and gave an enthralling talk to staff and students about his mission on the Space Shuttle Discovery to the International Space Station.

He took the audience through the eight year preparation for the trip which featured:

- A test for claustrophobia that consisted of being zipped into a large 'beach ball' while wearing heart rate monitors.
- Living on the ocean floor in an undersea base, with other potential crew members.
- A team-building two week trek into the desert.
- A zero gravity flight which astronauts call the "vomit comet", in which an aeroplane flies in such a way that people inside are temporarily weightless.
- Continual intensive technical training throughout the eight year period.

Nicholas returned to the Department the medal, which he took into space strapped to his flight check list. The medal designed and made by Ali Khan and Alastair Ross, was specially etched in the Department on surgical grade stainless steel using high power laser. Nicholas signed the medal and also gave the Department a commemorative plaque with pictures of the mission and a Union Jack flag that went into space. These were presented to Keith Glover, Head of Department, and will be displayed in the entrance area within a few weeks.

Nicholas spoke about the future of space travel explaining how America will send a new generation of explorers to the moon aboard NASA's Orion crew exploration vehicle. Making its first flights early in the next decade, Orion is part of the Constellation Program to send human explorers back to the moon, and then onward to Mars and other destinations in the solar system.

The commemorative plaque with pictures of the mission and a Union Jack that went into space

For more information on Nicholas' training and the mission please visit www.nasa.gov/mission_pages/shuttle/shuttlemissions/sts116/main/index.html

Current jet engine research in Whittle's centenary year

Sir Frank Whittle (1907-1996) known as the inventor of the jet engine, gained a BA with first class honours in the Mechanical Sciences Tripos here in the Department in 1936. The jet plane as we know it today has evolved from his original design and has been in operation around the world for just over 66 years.

The Whittle Laboratory was opened in May 1973 by Sir Frank Whittle and is a Research Group within the Energy Division of the Department of Engineering. There are 6 teaching staff, 9 research staff, 27 research students, 12 support staff, an industrial visitor and Professor Howard Hodson totalling 56 staff in all. The Laboratory specialises in the fluid dynamics and thermodynamics of all types of turbomachinery and has excellent contacts with industry, government bodies and other research organisations. The Whittle Laboratory is a part of the Rolls-Royce UGTP (University Gas Turbine Partnership) and is responsible for all research relating to Turbomachinery Aerodynamics.

In this, the centenary year of Whittle's birth, the key challenges facing aero-engine technology are reducing fuel burn, increasing operability and lowering noise. The modern jet engines of today have developed from Whittle's original design into highly efficient systems that can power huge aircraft for thousands of long-distance flights with minimal maintenance. However, this is not enough, and to meet our demands for continued, sustainable air travel, further improvements are needed. The research at the Whittle lab consists of a huge range of projects that are focused on addressing these challenges. Most of the projects are tied to industry and the results of many previous investigations have fed directly into the

Sir Frank Whittle (1907–1996)

design of jet engine components that are now flying around on thousands of aircraft.

It is becoming increasingly difficult to find ways of improving modern jet engines. Researchers at the Whittle have to look closer at the details of the engine components and to try to understand more complex aspects of turbomachinery aerodynamics. This is a theme of many of the current research projects. For example, there is the potential for large gains in engine performance if the flow around intricate geometrical features can be controlled. Previously, engine components have been simulated, both in tests and calculations, using simplified geometries. However, the real geometry in the engine is much more complex, and the performance of this can be significantly different. The figures below show an example comparison between calculations for a "simplified" and a "real" turbine geometry in an engine and how this affects the flow.

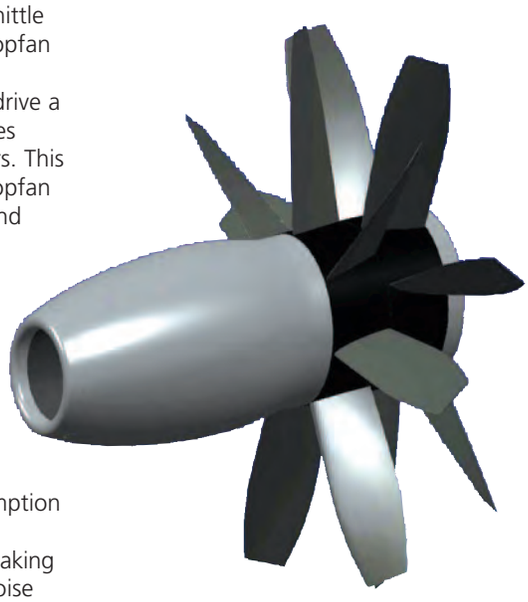
Another approach is to look to more radical configurations of aero engines for the future. One intriguing alternative that is the attention of research at the Whittle Laboratory is the "open-rotor" or propfan engine. This is similar to a turboprop engine, which uses a gas turbine to drive a propeller, except that the propfan uses specially shaped high-speed propellers. This has two main advantages. First, a propfan has no ducting around the engine, and without this bulky housing a major source of drag is removed. Secondly, by making use of specially shaped counter-rotating propellers, the design avoids generating "swirl" – the vortex of wasted energy that usually trails in the air behind aircraft propellers. There is the potential of 20-30% reduction in the fuel consumption of aircraft powered by such devices. However, one of the major issues is making open rotors acceptable in terms of noise and this is something that researchers at the Whittle Laboratory are tackling.

FACT BOX

The Department of Engineering has helped Quanta Films with access to some key Cambridge locations during the production of Quanta's documentary film, 'Whittle – the Jet Pioneer'. A feature-length version with extras is available on DVD from Quanta www.quantafilms.com/index.php/ The core of this fascinating documentary is an exclusive interview with Sir Frank Whittle filmed with Quanta films in 1986. It also contains contributions from his son Ian Whittle, veteran test pilot Captain Eric Brown RN and Hans von Ohain, who designed Germany's first jet engine.

Further information about the latest research on jet engines can be found at the Whittle Laboratory's website: www-g.eng.cam.ac.uk/whittle/

Further information about Sir Frank Whittle can be found on the Department of Engineering '125 years of Engineering Excellence' website: www-g.eng.cam.ac.uk/125/1925-1950/whittle.html



The open rotor engine geometry (A. Zachariadis)

Professor Gehan Amaratunga receives Royal Academy of Engineering's Silver Medal

Professor Gehan Amaratunga (right) receives Royal Academy of Engineering's Silver Medal

Professor Gehan Amaratunga has been presented with the Royal Academy of Engineering's Silver Medal, recognising outstanding personal contribution to UK engineering.

Gehan is Head of the Electronics, Power and Energy Conversion group at the Department. He receives the Silver Medal for his pioneering development of special silicon chips with built-in high voltage power-switching devices. These integrated circuits are used in the AC/DC converters essential for most consumer electronics. He has formed several successful companies to commercialise his work, including CamSemi and Enecsys. His latest project is to develop nanoscale supercapacitors to replace batteries in products from electric vehicles to PDAs. Gehan and his team have grown forests of multi-walled carbon tubes just billionths of a metre wide. When sandwiched with silicon nitride between niobium and aluminium electrodes they create a tiny capacitor that packs a real punch in terms of energy storage.

Presenting the Medals, Lord Browne of Madingley, RAE president, said: "The greatest inventor is the engineer. Engineers approach a problem in a manner which is both visionary and realistic – they draw simultaneously on science and business to provide solutions to challenges through the application of new technology."

Further information on the awards can be found on The Royal Academy of Engineering website: www.raeng.org.uk/news/releases/shownews.htm?NewsID=393

CAPE beams up new partner for nanotech research

The Director of CAPE Professor Bill Milne (right)

Chairman of the CAPE Steering Committee Professor Bill Crossland

Dr David Holburn who leads the Department's work on scientific imaging and fostered the relationship with Carl Zeiss

A new partnership is set to give nanotechnology researchers at the University of Cambridge access to the latest electron-beam imaging equipment.

The Centre for Advanced Photonics and Electronics (CAPE) is joining forces with the global nano-manufacturing supplier Carl Zeiss SMT.

The deal means that scholars will have access to Carl Zeiss' instruments and expertise in electron beam imaging, including two state-of-the-art scanning electron microscopes, which the firm has donated to the Centre.

CAPE, which is part of the Department of Engineering, is a unique partnership between the University and four major industrial partners that develops and commercialises new materials, components and systems in the field of electronics and photonics. It has already attracted international attention not only for its work, but also as a model of university-industry collaboration.

Carl Zeiss will become the CAPE Associate for Electron Beam Imaging. Electron microscopy allows the user to see the fine detail of materials and probe their composition, making it immensely valuable for the study of nanostructures.

The very first successful scanning electron microscope was built at Cambridge under the leadership of Professor Charles Oatley in 1951, and the University also has a long-standing connection with Carl Zeiss. In the late 1950s the Cambridge Instrument Co. was licensed to manufacture these microscopes, and one of Oatley's students joined the company to design a commercial version of the instrument, which was a great success. Later the company was acquired by Carl Zeiss. Collaborations between the University and the company have continued ever since.

Professor Bill Milne, Director of CAPE, said: "The addition of Carl Zeiss SMT as our new Associate Partner will greatly enhance our capability, given our large and growing interest in a variety of different nanostructure materials."

Dr Stefan Traeger, General Manager of the Cambridge branch of Carl Zeiss SMT said: "The first commercially available scanning electron microscope in 1965 was a result of the strong link between the University and Cambridge Instruments at that time. I am certain that with this association our projects will result in exciting solutions for the nano-age world."

Further information on the Centre for Advanced Photonics and Electronics visit www-cape.eng.cam.ac.uk.

FACT BOX

The very first successful scanning electron microscope was built at Cambridge under the leadership of Professor Charles Oatley in 1951.

Professor Ian Hutchings is awarded the Staudinger-Durrer Prize

Professor Ian Hutchings

The Staudinger-Durrer Medal (Silver)

Professor Ian Hutchings gave the Staudinger-Durrer lecture at the ETH Zurich (Swiss Federal Institute of Technology, Zurich) where he was awarded the Staudinger-Durrer Prize and Medal.

The lecture was given as part of the Materials Day 2007 – 'Sticking and Sliding, Wearing and Tearing symposium' which addressed research at the cutting edge of sticking and sliding, wearing and tearing, and its significance for Materials Science, Biology, Mechanical and Manufacturing Engineering. Ian's lecture was on 'Manufacturing by subtractive and additive processes: wear and inkjet printing'. New experimental techniques involving high-speed photography and digital image analysis are being used at the Department's Inkjet Research Centre to study the development of small-scale liquid jets and drops, and recent results from this work were reviewed.

To emphasize the importance of Materials Science at the ETH Zurich (Swiss Federal Institute of Technology, Zurich), the Department of Materials awards the Staudinger-Durrer Prize at its Materials Day. The prize serves to honour those who have rendered outstanding services to materials science, and is named after two of the major scientists in the field to emerge from the ETH Zurich in the 20th century: Hermann Staudinger and Robert Durrer.

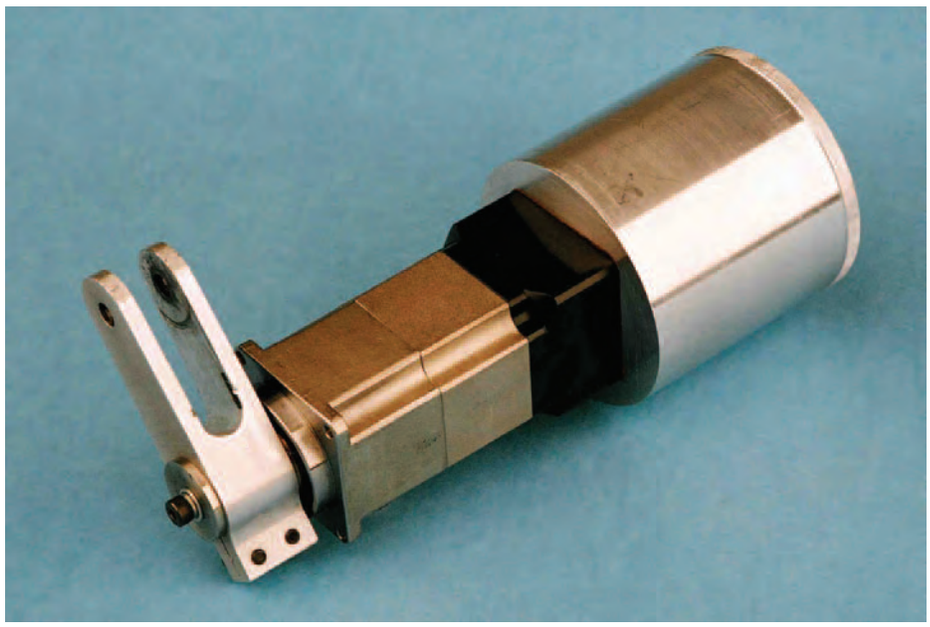
Hermann Staudinger was Professor at the ETH-Zurich in the period 1912-1926, In 1953 he won the Nobel Prize in chemistry for his pioneering work in the field of macromolecules. Robert Durrer was Professor at the ETH from 1943 to 1961. He laid the foundation for oxygen-based metallurgy, the so-called LD (Linz-Durrer) process.

For more information on the Materials Day 2007 – Sticking and Sliding, Wearing and Tearing symposium please visit www.materialsday.mat.ethz.ch.

For more information on the Staudinger-Durrer Prize please visit www.mat.ethz.ch/

Control of motorcycle steering instabilities

Front cover of IEEE Control Systems Magazine, Advances in Motorcycle Design and Control, edited by A. Beghi and R. Frezza October 2006 issue



Prototype motorcycle steering compensator designed by N.E. Houghton and manufactured in the Engineering Department

The Department's Professor Malcolm Smith has been working on steering compensation for high-performance motorcycles.

An article on the subject has recently appeared in the IEEE Control Systems Magazine reporting on joint work of the Cambridge and Imperial College control groups (S. Evangelou, D.J.N. Limebeer, R.S. Sharp and M.C. Smith, Control of Motorcycle Steering Instabilities – Passive Mechanical Compensators Incorporating Inerters, IEEE Control Systems Magazine, October 2006, pp. 78-88). The article proposes the use of a "passive mechanical steering compensator" to control simultaneously both the "weave" and "wobble" modes of oscillation. The compensator exploits the "inerter" concept and device previously developed by Malcolm Smith in the context of vehicle suspension.

It is well-known that motorcycles can exhibit oscillations under certain operating conditions that may be lightly damped or even unstable. Such oscillations can limit the lap times achievable by riders of racing machines. They also present serious safety risks and have been the cause of accidents. The most important of these modes are wobble and weave. Wobble is a steering oscillation that is reminiscent of the caster shimmy that occurs in the front wheels of a supermarket trolley, while weave is a fish-tailing type motion involving roll and yaw. The frequency of the wobble mode is of the order 8 Hz, while the weave frequency is about 3 Hz, where the exact figures depend on the speed and type of machine. Motorcycle design necessitates trade-offs between weave and wobble. For example, a conventional steering damper tends to stabilise wobble but destabilise weave.

A prototype steering compensator has been built and tested in the Engineering Department.

The inerter is a passive, mechanical device with two terminals (attachment points) with the property that the equal and opposite applied force at the two terminals is proportional to the relative acceleration between them. In rotational form, the inerter provides a torque proportional to relative angular acceleration. The inerter, spring and damper, give an exact analogy with the capacitor, inductor and resistor in electrical circuits. The most general, realisable mechanical impedance can be built with springs, dampers and inerters (but not with springs, dampers and masses, since the mass element effectively has only one moveable terminal). A number of contrasting embodiments of inerters have been built in the Engineering Department. Simulations carried out together with Imperial College have shown that the inerter has a roughly opposite tendency to the damper regarding steering oscillations. Namely, the inerter is stabilising for weave but not for wobble. The key idea proposed in the article is to employ an inerter in series with a damper tuned in such a way that the weave mode damping is improved by the inerter and the wobble mode damping is improved by the damper. A prototype steering compensator has been built and tested in the Engineering Department. A full technical paper on this work has recently appeared in S. Evangelou, D.J.N. Limebeer, R.S. Sharp and M.C. Smith, 2007, Steering compensation for high-performance motorcycles, Transactions of ASME, Journal of Applied Mechanics, vol. 74, 332-346.

For further information please contact: Professor Malcolm Smith, e-mail: mcs@eng.cam.ac.uk

Nanotube formation captured on video

A team of scientists led by the Department's Dr Stephan Hofmann have successfully produced live video footage that shows how carbon nanotubes, more than 10,000 times smaller in diameter than a human hair, form.

The video sequences show nanofibres and nanotubes nucleating around miniscule particles of nickel and are already offering greater insight into how these microscopic structures self-assemble.

The videos show how the nickel reacts, a process called catalytic chemical vapour deposition (CVD). This is one of several methods of producing nanotubes, and involves the application of a gas containing carbon (in this case acetylene) to minute crystalline droplets referred to as "catalyst islands" (the nickel).

In conditions appropriate to creating nano-fibres, the catalyst was squeezed upwards gradually as carbon formed around it. When the application of gas was reduced to create single-walled nanotubes, the carbon instead lifted off the catalyst to form a tubular structure.

In particular, the team discovered that the carbon network is guided into tubular shape by a drastic restructuring of the nickel – the catalyst in the process. They were also able to track and time the deposition of the carbon around the nickel.

Carbon nanotubes are new building blocks enabling engineers to improve and further miniaturise everyday electronic devices like computers or mobile phones. At the moment scientists can grow nanotubes but cannot accurately control their structure. Being able to do so is vital as it is the very structure of a nanotube that dictates its properties. The nano-scale video observations mean that scientists will be able to understand better the nucleation of nanotubes and are therefore an important step on the route towards application. The two sequences show action taking place in real time on an astonishingly small scale. The difference in size between a single-walled nanotube and a human hair is close to the difference between the same human hair and the Eiffel Tower. The microscopic scale involved has, in the past, made it difficult to understand the growth process.

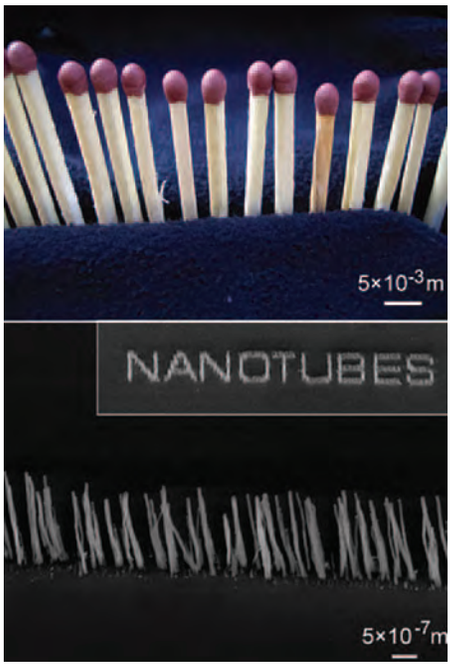
The team used X-rays produced at a synchrotron (a type of particle accelerator) and a modified high-resolution transmission electron microscope to observe and film the catalytic chemical vapour deposition process.

As the gas is applied, carbon sticks to the catalyst islands forming layers of graphite. In conditions appropriate to creating nanofibres, the nickel particle was pushed upwards in a series of peristaltic movements as the carbon continued to deposit on its sides. At several points the nickel formed a cap which almost "popped" out of the forming tube, leaving a layer of graphite behind it. This process is called "bambooing", because the resultant carbon nanofibre is a cylinder containing several cavities, each one separated by one of these graphite layers, similar in form to bamboo. Throughout the whole process, the nickel remained crystalline rather than liquid.

The team then looked at conditions more appropriate to producing single-walled carbon nanotubes, which involved less acetylene. The catalyst is not squeezed upwards. Instead, a cap of carbon formed on the top of the nickel, and gradually extended from it to form a tubular structure. The catalyst island was squeezed and reshaped by this process and was moulded by the carbon forming around it rather than retaining its original form. Dr Stephan Hofmann said: "In order to reach the full application potential for nanotubes, we need to be able to control their growth accurately first. As a manifestation of the impressive progress of nanometrology, we are actually now able to watch molecular objects grow. This new video footage shows that the catalyst itself remains crystalline but is constantly changing its shape as the carbon network is formed around it.

"We cannot yet solve the problem of not being able to self-assemble carbon nanotubes with well-defined characteristics, but we have discovered that if we are to do so, we need to be mindful not just of the carbon dynamics but the changing shape of the catalyst as well."

The video sequences can be viewed on the Department of Engineering website at: www.eng.cam.ac.uk/news/stories/2007/Nanotubes/



Size scale in context: (a) the diameter of a match is on the mm (10-3m) scale and can be seen by naked eye, whereas (b) the diameter of an as-grown nanofibre measures only few nanometers (10-9 m), a size so small that it could be only resolved in recent decades by advancing electron microscopy and scanning probe techniques. The nanotubes can be up to a million times smaller than the match. The functional head of a match also resembles the catalyst particle riding at the tip of the growing nanostructure during CVD.

For further information please contact Dr Stephan Hofmann email: sh315@cam.ac.uk or visit his webpage: www g.eng.cam.ac.uk/edm/people/sh315.html

FACT BOX

Carbon nanotubes are new building blocks enabling engineers to improve and further miniaturise everyday electronic devices like computers or mobile phones.

'Discover Engineering' family workshops

Teamwork

The race

A series of 'Discover Engineering' family workshops, have been a resounding success here at the Department. They aim to introduce young people (7-12) to the fun and excitement of engineering and technology. Joy Warde, the Department's Outreach Officer, commenting on the workshops said, "The key to their success are the enthusiastic teams of student volunteers who help to make engineering more accessible and to provide role models for the next generation of engineers".

The format of each workshop is quite simple: the families design and make their car, hovercraft or crane from a simple kit. The student volunteers act as 'engineering consultants' to advise the teams on their design. Each workshop ends with a 'race-off' to find the fastest car or hovercraft or the strongest crane. There is an additional prize for the most stylish creation as judged by the student volunteers.

Over the 4 events this year 300 family teams attended (1200 people). They were assisted by 50 undergraduate and postgraduate student volunteers.

Below are a few of the comments from parents and children attending the events:

"It was good because there was plenty of emphasis on the FUN!!!"

"A great introduction to Engineering"

"Excellent event, highly entertaining and educational for the children and parents alike. Thank you to all of the students for giving up their free time."

"The event was well organised and the student helpers were excellent."

Peter Ward, a member of the Cambridge University Engineers' Association, wrote the following summary of his day as a volunteer at one of the family workshops:

Cunning cantilevers
A bracing experience was provided in a hands-on Crane Construction Challenge issued by the Engineering Department as part of the two-week University Science Festival in mid-March this year. Contenders were invited to build a horizontal beam for a hypothetical tower crane from paper tubes.

A4 sheets were rolled into 20 or 30 cm paper cylinders, sealed, then flattened and pierced at the ends. Using nuts and bolts, participants assembled them into a three-dimensional, 60-cm-long, lattice. Made to the ingenious and wondrous designs of attending families, who constantly rolled up to fill the floor space available, these cantilevers were then tested to destruction.

Know-how. A sheet of simple instructions was provided, pointing out, for example, that, unlike a triangle, a square frame (bolted together at the corners) was not firmly rigid and could be squashed unless given a diagonal cross bracing; and that, unlike concrete (robust when compressed), paper tubes were stronger in tension and inclined to buckle in compression.

The young contestants who, with family helpers, replaced each other in roughly

FACT BOX

This year 720 primary school pupils and teachers have visited the Department for the 'rocket launch-pad' challenge.

350 secondary school pupils from Headstart, Sutton Trust, National Academy of Gifted and Talented Youth (NAGTY), HEFCE, and GEEMA Summer Schools have participated in activities designed to promote engineering.

Approximately 1200 young people and parents have attended a 'Discover Engineering' Workshop. This includes 800 people who participated in 'Crane Construction Challenge' during the Cambridge Science Festival 2007.

hourly cycles (a sort of dynamic equilibrium), occupied two large floors at the University Centre in Mill Lane, where the Challenge was held.

On their way there, they may have seen, rising in the sky above one of Cambridge's current construction sites, the tall slender stalk of a tower crane, with at the top an equally fine horizontal lattice like a straight branch reaching far out from the stem (and balanced no doubt with a weight at the rear) above the work area. It was this load-carrying beam that those taking part were to reproduce from linked paper tubes, with minimum waste of materials.

All-sorts. A few elderly members of the CU Engineers' Association, myself included, volunteered to guide and invigilate, along with some friendly, young initiates from the Engineering Department; at least, I did my best to reassure and encourage, hoping to recruit some young innovators as future engineers.

Loaded. The two-foot cantilever lattices were, in turn, attached by strings to opposite sides of a free-standing cabinet serving as a twin tower, with help from skilled testers – on my left, a Canadian and, on my right, an Austrian student – hanging buckets on the ends and loading them progressively with large baked-bean tins.

In early tests, buckling at four tins was a fair score but later the numbers rose into the "teens". Towards the end of the session a monstrous construction appeared, comprising a lower beam made from multiple tubes bound into a single thick branch, wrapped in sticky tape (provided as part of the "kit"), and supported by a thin catenary or chain of paper tubes, fixed as high as possible on the tower. Loading continued, eventually accompanied by a counting chant, until the bucket was full and, slowly, the lower, compression rod began to collapse. In the end redundancy proved a winner.

I turned to a youngster in the team and said "You must have an expert". "Yes", he replied proudly, "he's my dad". Later the Canadian student told me: "Actually, he's a member of the faculty" (in the Department). It took me back, some sixty years, when one demonstrator, a young and very modest Lord Caldecote, had assisted me in performing an indicator test. Not long afterwards I wrote an article, in which I noted: "Engineering is the ideal academic discipline, combining, as it does, the rigorous reasoning of science with the bloody-mindedness of life." What could inspire young people more?

Crane construction challenge

This series of workshops are sponsored by University of Cambridge Active Community Fund and Research Councils UK.

There are further family workshops planned for the next academic year. Details will be available on the outreach website in September.

These workshops are just part of the Department's outreach calendar of events, during the academic year 2006/07 over 110 engineering students, staff and alumni have donated over 1200 hours as outreach volunteers. 57 of these volunteers have become Science and Engineering Ambassadors (SEAs).

For more information on the Outreach activities please visit www.eng.cam.ac.uk/outreach/index.html

UNIVERSITY OF CAMBRIDGE
Department of Engineering

Editor, Jacqueline Saggers
Department of Engineering
University of Cambridge
Trumpington Street
Cambridge CB2 1PZ
Telephone: +44 (0)1223 748228
Email: marketing@cam.ac.uk
Website: www.eng.cam.ac.uk

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